Final Technical Report

NASA Grant NGL - 33-010-054

for

SONIC BOOM RESEARCH

Principal Investigator:

A. Richard Seebass

Co-Principal Investigator:

Albert R. George

Technical Officer:

Raymond L. Barger

NASA Langley Research Center

August, 1974

Period of Grant:

September 1, 1967 - August 31, 1974

Institution:

Cornell University

Ithaca, New York 14850

Final Technical Report

The results from sonic boom research conducted under NASA Grant NGL-33-010-054 are detailed in the publications listed below. This research had the following goals: 1) minimization of the sonic boom of SST generation aircraft; 2) prediction of the distortion of the sonic boom signature by atmospheric turbulence; 3) prediction of the amplification that occurs at a caustic, known as the superboom. Despite advances in these areas, further research is required in several of them and is being conducted under NASA Grant NGR-33-054-203, along with other studies.

As a result of research on this grant it is now a routine matter to determine the aircraft area distribution required to minimize various sonic boom signature parameters for given aircraft weight, length, flight altitude, Mach number, and volume; this minimization includes a reasonable latitude in the choice of the front-to-rear shock strength ratio. We now understand the basic phenomena that cause distortion of sonic booms by atmospheric turbulence and can, on a single event basis, predict signature waveforms that agree reasonably well with those measured by the NASA. We have been able to make qualitative predictions about the magnitude of the superboom, particularly that associated with threshold operations, and can scale these results to other flight conditions by the basic nonlinear similitude.

SONIC BOOM PUBLICATIONS

Sonic Boom Research, edited by A. R. Seebass, NASA SP-147, 1967, 118 pp.

"The Possibilities for Reducing Sonic Boom by Lateral Redistribution," A. R. George, Sonic Boom Research, NASA SP-147, 1967, pp. 83-94.

"Multipoles, Waveforms, and Atmospheric Effects," A. R. George and A. R. Seebass, Second Conference on Sonic Boom Research, NASA SP-180, 1968, pp. 133-144.

"General Remarks on Sonic Boom," A. R. Seebass, Second Conference on Sonic Boom Research, NASA SP-180, 1968, pp. 175-180.

"Brief Comments on Sonic Boom Reduction," A. R. George, Second Conference on Sonic Boom Research, NASA SP-180, 1968, p. 192.

"Minimum Sonic Boom Shock Strengths and Overpressures," R. Seebass, Nature, vol. 221, 1969, pp. 651-653.

"Reduction of Sonic Boom by Azimuthal Redistribution of Overpressure," A. R. George, AIAA Journal, vol. 7, no. 2, 1969, pp. 291-297.

"Sonic Boom Theory," R. Seebass, J. Aircraft, vol. 6, no. 3, 1969, pp. 177-184.

"Lower Bounds for Sonic Booms in the Midfield," A. R. George, AIAA Journal, vol. 7, no. 10, 1969, pp. 1542-1545.

"Sonic Boom Waveforms in a Real Atmosphere," A. R. George and K. J. Plotkin, AIAA Journal, vol. 7, no. 10, 1969, pp. 1978-1981.

"Round Table Discussion of Sonic Boom Problems - Sonic Boom Minimization," R. Seebass, AGARD Proceedings on Aerodynamic Noise and Sonic Boom, no. 42, 1969, pp. 35-46.

"Weak Shocks in Turbulent Media," K. S. Plotkin and A. R. George, AIAA Paper No. 70-54, 1970.

"The Effects of Atmospheric Inhomogeneities on Sonic Boom," A. R. George, Third Conference on Sonic Boom Research, NASA SP-255, 1971, pp. 33-58.

"Perturbations behind Thickened Shock Waves," K. J. Plotkin, Third Conference on Sonic Boom Research, NASA SP-255, 1971, pp. 59-66.

"Nonlinear Acoustic Behavior at a Caustic," R. Seebass, Third Conference on Sonic Boom Research, NASA SP-255, 1971, pp. 87-122.

"Finite Difference Calculation of the Behavior of a Discontinuous Signal near a Caustic," R. Seebass, E. M. Murman, J. A. Krupp, Third Conference on Sonic Boom Research, NASA SP-255, 1971, pp. 361-372.

"The Accuracy of the Landau-Whitham Shock Strength Rule in Some Near-Field Situations," A. R. George and W. K. Van Moorhem, Third Conference on Sonic Boom Research, NASA SP-255, 1971, pp. 373-384.

"Comments on Sonic Boom Research," R. Seebass, Third Conference on Sonic Boom Research, NASA SP-255, 1971, pp. 411-412.

"The Effect of Atmospheric Inhomogeneities on the Sonic Boom," K. J. Plotkin, Ph.D. Thesis, Cornell University, 1971, 180 pp.

"Propagation of Sonic Booms and other Weak Nonlinear Waves through Turbulence," A. R. George and K. J. Plotkin, Phys. Fluids, vol. 14, no. 3, 1971, pp. 548-554.

"Sonic Boom Minimization Including Both Front and Rear Shocks," A. R. George and R. Seebass, AIAA Journal, vol, 9, no. 10, 1971, pp. 2091-2093.

"Focusing of Finite-Amplitude Cylindrical and Spherical Sound Waves in a Viscous and Heat-Conducting Medium," T. C. Chu, Ph.D. Thesis, Cornell University, 1971, 92 pp.

"Sonic-Boom Minimization," R. Seebass and A. R. George, J. Acoustical Soc. of Am., vol. 51, no. 2, 1972, pp. 686-694.

"Reply to Comments of A. D. Pierce, " A. R. George and K. J. Plotkin, Phys. Fluids, vol. 15, no. 5, 1972, p. 954.

"Propagation of Weak Shock Waves through Turbulence," K. J. Plotkin and A. R. George, J. Fluid Mech., vol. 54, part 3, 1972, pp. 449-467.

"Sonic Boom Reduction Through Aircraft Design and Operation," A. R. Seebass and A. R. George, AIAA 11th Aerospace Sciences Meeting, AIAA Paper No. 73-241, 1973.

"The Design or Operation of Aircraft to Minimize Their Sonic Boom," R. Seebass, AIAA Paper No. 73-817, 5th Aircraft Design, Flight Test and Operations Meeting, St. Louis, Mo., August 6-8, 1973.

"Nonlinear Acoustic Behavior at a Caustic: An Approximate Analytical Solution," P. M. Gill and A. R. Seebass, AIAA Aero-Acoustics Conference, Seattle, Washington, October 15-17, 1973, (to appear as proceedings).

"Acoustic Behavior of a Discontinuous Signal Near a Caustic," K.-Y. Fung and A. R. Seebass, Appendix C of Analysis of Sonic Boom Measurements near Shock Wave Extremeties for Flight near Mach 1.0 and for Aircraft Acceleration, by G. T. Haglund and E. J. Kane, Boeing Document D6-22547, November 1973.

"Nonlinear Acoustic Behavior at a Caustic, An Approximate Analytical Solution," P. M. Gill, Ph.D. Thesis, Cornell University, 1974, 62 pp.